

REMARKS

Regarding the §102(b) rejection

Claims 8, 9, 13-16, 20-23, 35 and 36 stand rejected as anticipated by Kang et al. (USP 6,174,809). This rejection is traversed for the reasons set forth below.

Claims 35 and 36 of this application are in independent form. Both of these claims are to a method of producing a thin metal film on a solid substrate. The method of claim 35 includes the following process steps:

(a) contacting said solid substrate surface with a metal halide gas, wherein the metal is selected from the group consisting of tungsten, rhenium, molybdenum, antimony, selenium, thallium, chromium, platinum, ruthenium, iridium, and germanium, under conditions including a temperature from 425 to 600 K sufficient to deposit a layer of said metal halide on said solid substrate surface;

(b) thereafter contacting said surface with a reducing agent consisting of a gaseous silylating agent under conditions including a temperature from 425 to 600 K, such that the silylating agent reacts with metal halide species on said solid substrate surface to form silane moieties at the surface of the substrate;

(c) then contacting said surface with additional metal halide gas under conditions including a temperature from 425 to 600 K such that the additional metal halide gas reacts with the silane moieties formed at the surface of the substrate in step (b) to form a metal film layer having metal halide surface species;

and thereafter sequentially repeating steps (b) and (c) one or more additional times, whereby in each cycle of steps (b) and (c), the metal halide and silylating agent react to produce a metal film layer having a thickness substantially corresponding to the atomic spacing of said metal.

Claim 35 is therefore drawn to a specific process, characterized in part by the selection of specific reagents, specific temperatures, and, importantly, the sequential performance of the individual steps in the process.

As stated in the last response, this invention solves several problems. One problem is the need to form ultrathin, high quality metal films on various substrates. Another problem is to make those films at a controlled thickness. A third problem is to make high purity metal films, and in particular films that have minimal silicon and halide contamination. A fourth problem is to make the film under reasonable production conditions, so that substrate thermal damage is minimized and a larger range of substrates can be used.

Summary of Main Differences Between Kang and the present invention.

The Kang reference does not anticipate any of the pending claims for several reasons. At least some of those reasons can be summarized as:

1. Kang does not contain a specific disclosure of step (a) of applicant's process, in which a tungsten, rhenium, molybdenum, antimony, selenium, thallium, chromium, platinum, ruthenium, iridium or germanium halide gas is contacted with a solid substrate at a temperature of 425-600K. Kang contains only a general disclosure as to temperature (300-500°, corresponding to 573-773K) and describes a very wide range of potentially usable metals and metal precursors (only some of which are halides). Nothing in Kang points to the specific selection of these specific metal halides together with a small fraction of Kang's general temperature range.

2. Kang's process does not deposit a layer of metal halide on the substrate surface, as required in step (a) of claims 35 and 36. Kang simultaneously introduces a metal halide and reducing agent. In effect, Kang's process is a CVD process as described in the previous response. When Kang deposits metals in this way, the metal halide is immediately reduced and the resulting metal layer lacks halide atoms.

3. Kang's process does not include a step corresponding to applicant's step (b). In cases where Kang uses a silylating agent, he does not deposit it onto a previously-formed metal layer having metal halide species on the surface. Kang either introduces the silating

agent simultaneously with a metal halide gas, or else introduces the silylating agent onto a previously-reduced metal layer from which halide atoms have been removed.

4. Kang does not contain a disclosure of step (b) of applicant's process step (b), in which a silyating agent is contacted with an underlying metal layer at a temperature of 425-600K. As before, Kang's general teachings as to temperature do not disclose applicant's specific temperature range in conjunction with the silylating agent.

5. Kang does not contain a specific disclosure of step (c) of applicant's process, in which a tungsten, rhenium, molybdenum, antimony, selenium, thallium, chromium, platinum, ruthenium, iridium or germanium halide gas is contacted at a temperature of 425-600K with an underlying metal layer having surface silane moieties. As before, Kang's general teaching of a broad temperature range does not amount to a specific teaching of applicants' selection of metal halides and temperatures.

6. Kang does not describe sequentially repeating steps (b) and (c) of applicant's process to produce in each reaction cycle a metal layer having a thickness substantially corresponding to the atomic spacing of the metal.

Kang's Processes

Kang's disclosure actually describes several processes. These are:

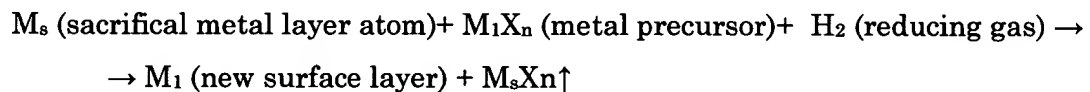
1. deposition of an "initial sacrificial metal layer"
2. deposition of a "sacrificial metal atomic layer"
3. deposition of a "metal atomic layer"
4. deposition of a "silicon atomic layer".

Kang's initial sacrificial metal layer and sacrificial metal atomic layers are each made in the same way, as described most particularly in column 5 line 7 through column 8 line 37. Kang forms these by simultaneously introducing the sacrificial metal precursor and the reducing gas. *See especially* column 5 line 7 et seq. ("second, fourth and fifth valves V2, V4 and V5 are opened", referring to Figure 6), and Kang's Figures 2 and 4, each of which unambiguously illustrates that the reducing gas is added continuously throughout Kang's process. Kang then follows up with an additional hydrogen plasma treatment to complete

the metal reduction process. See column 9 lines 13-22. Even if one were to use a metal halide precursor material to form a sacrificial layer in Kang's process, his method ensures that the halide is reduced and does not form a metal layer with surface metal halide species, as required by steps (a) and (c) of the applicants' claims.

Kang deposits his metal atomic layer in a metal exchange process. A different metal is deposited over the sacrificial layer(s), causing the sacrificial layers to be consumed and removed. This is explained at column 9 line 48 through column 10 line 31.

During the metal exchange process, a metal precursor is again introduced together with reducing gas. The metal precursor reacts with the previously-deposited metal layer, in a reaction that can be summarized as:



This reaction does not correspond to any of steps (a), (b) or (c) of applicant's claims. Note that the reducing gas is again introduced *simultaneously* with the metal precursor. See Figures 2 and 4. The resulting layer contains neither halide nor silane moieties at its surface. Kang makes this quite clear at column 10, lines 30-32 ("the Ti layer formed according to one embodiment of the present invention contains no impurities, only Ti atoms").

At column 10 line 36 *et seq.*, Kang describes depositing a silicon atomic layer. This silicon layer is deposited over a metal atomic layer, which as we have already seen does not contain halide or silane surface moieties. Kang deposits this layer by simultaneously feeding in a silicon gas source and hydrogen (Fig. 4). The silicone gas source does not react with metal halide groups on the surface of the underlying metal layer, because those metal halide groups are not present in Kang's process.

In Kang's process, the silicon atomic layer reacts with the underlying metal layer to form a metal silicide (such as $TiSi_2$). See column 10 lines 50-55. This is altogether different than what occurs in of applicant's process, in which the surface silane groups are removed

in the reaction during steps (c), forming a metal layer rather than a metal silicide layer. The significance of the inventive process in forming a highly pure metal film has been explained in responses to earlier office actions.

Kang's process is therefore different from that now claimed in terms of process steps and results. Kang does not anticipate the invention as now claimed.

Regarding the §103 rejection

The §103 rejection is based on the combination of Kang with USP 5,681,775 to Pogge, with the Pogge reference being relied on for its description of surface hydroxylation. Kang fails to teach the process steps of the independent claims, and no combination of Kang and Pogge leads to such a process. This rejection fails for the reasons set forth above.

Conclusion

All claims now pending in this application have been shown to be novel and unobvious over the cited references. A timely notice of allowance is therefore respectfully requested. The undersigned is available by telephone if a call would advance prosecution.

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